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## **Public Charging User Experience: Are you doing it right?**

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### **Summary**

The user experience (UX) at public charging stations varies widely. This presentation is based on extensive data generated by thousands of ChargeHub users and the experience gained through a 35,000+ miles EV road trip through all 48 contiguous states. It summarizes the true status of the public charging in North America both from a quantitative and from a qualitative point of view. Beyond providing a complete picture of the Canadian and American infrastructure, it gives clear action items to anyone looking to improve public EVSE usage. It's a must for all players of the public charging value chain: utilities, governments, municipalities, OEMs, networks, NGOs and EV advocacy groups.

*Keywords: business model, Canada, consumers, infrastructure, United States of America*

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### **1 Introduction**

There is no doubt that the quantity of public EV charging stations in North America is growing rapidly. This is good news for current and future EV drivers. However increasing quantity means very little if the **quality** of the public charging experience isn't up to par. Examples of sub-par charging experience include broken stations, inaccessible stations, complex activation, bad positioning, hostile hosts and many more.

The product of the quantity and the **quality** of charging station locations in a given area is the true measure of “chargeability” in this area. This paper first provides an overview of quantitative metrics for public charging stations in both the U.S. and Canada. Following this, it focuses on the **quality** aspect of public EV charging in North America which is referred to as charging user experience (UX). Charging UX is analyzed based on different location attributes.

The most common UX issues faced by EV drivers are presented and means of mitigating them are proposed.

The paper concludes with simple but a detailed five point check list that existing and future charging station owners and stakeholders can use to ensure high quality charging UX.

All the data presented is gathered from the ChargeHub Data service.

## 2 Public Charging Stations Overview – Canada & U.S.

Today there are over 35,000 public Level 2 (L2) and DC Fast Charging (DCFC) stations in North America.

Fig. 1 below shows the increase in active charging stations in the last year in Canada and the U.S..

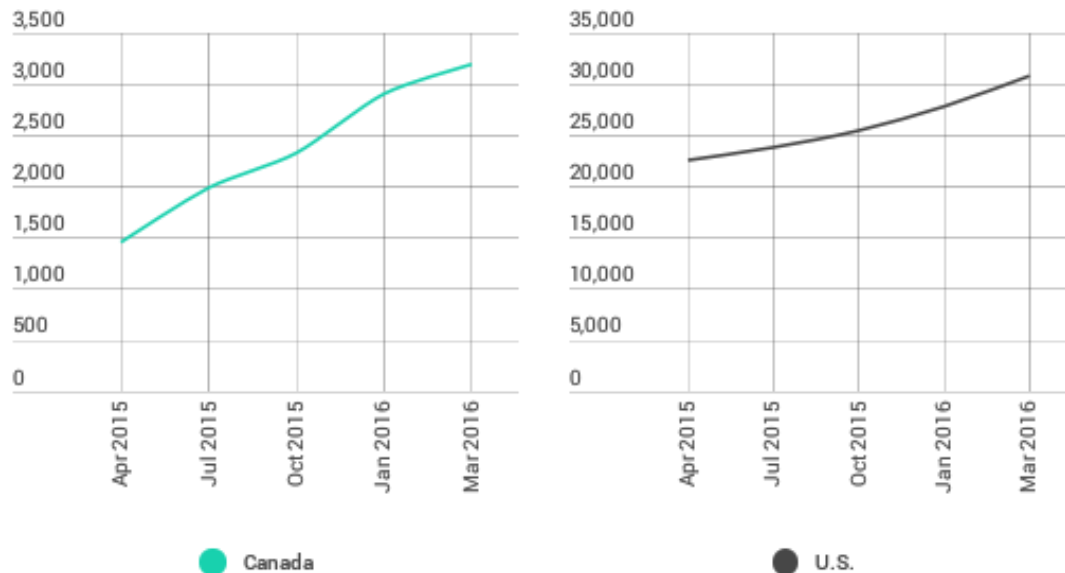


Figure 1: Total Number of Active Charging Stations vs. Time (Canada & U.S.)

The rate at which new charging stations are being deployed does show some seasonality (especially in Canada), but overall it has been increasing year over year for the past three years. Fig. 2 below shows how this rate evolved in the last year in Canada and the U.S.. For the period under review, Canada averaged 158 charging station installations per month while the U.S. had a monthly average rate of 749 charging stations being installed.

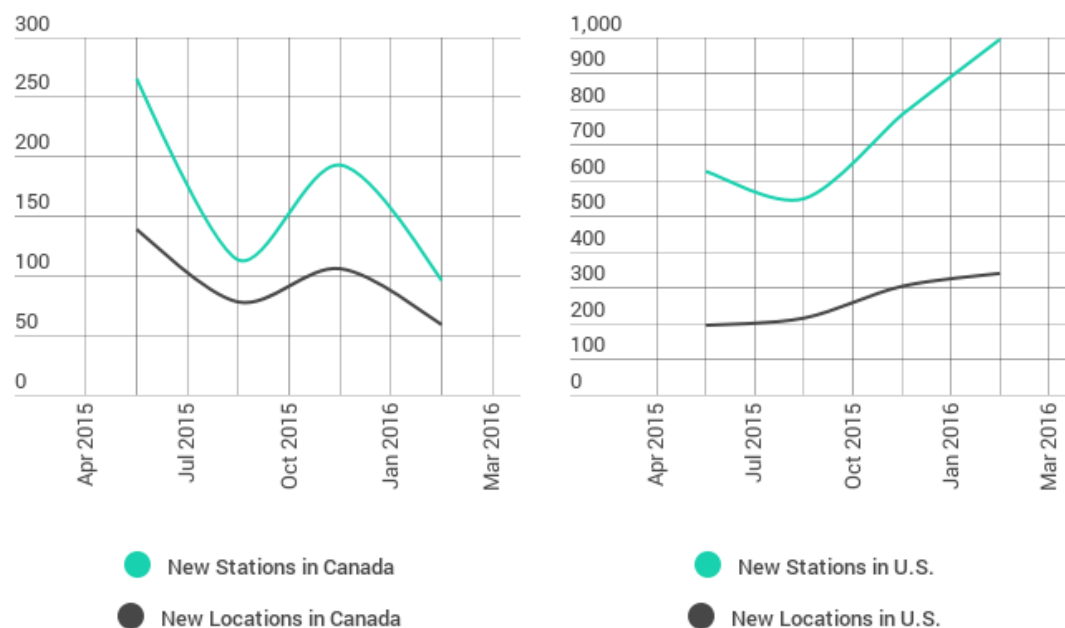


Figure 2: New Charging Stations & Locations in the Past Year vs. Time (Canada & U.S.)

On average, each location has 1.6 charging stations in Canada while in the U.S. each location has 2.4 charging stations. One interesting “outlier” when it comes to the number of charging stations per locations is Tesla Supercharger installations. As seen in Fig. 3 below, Tesla Supercharger installations have on average 3.8 times more stations per location than the Canadian average and 2.7 times more than the national average in the U.S..

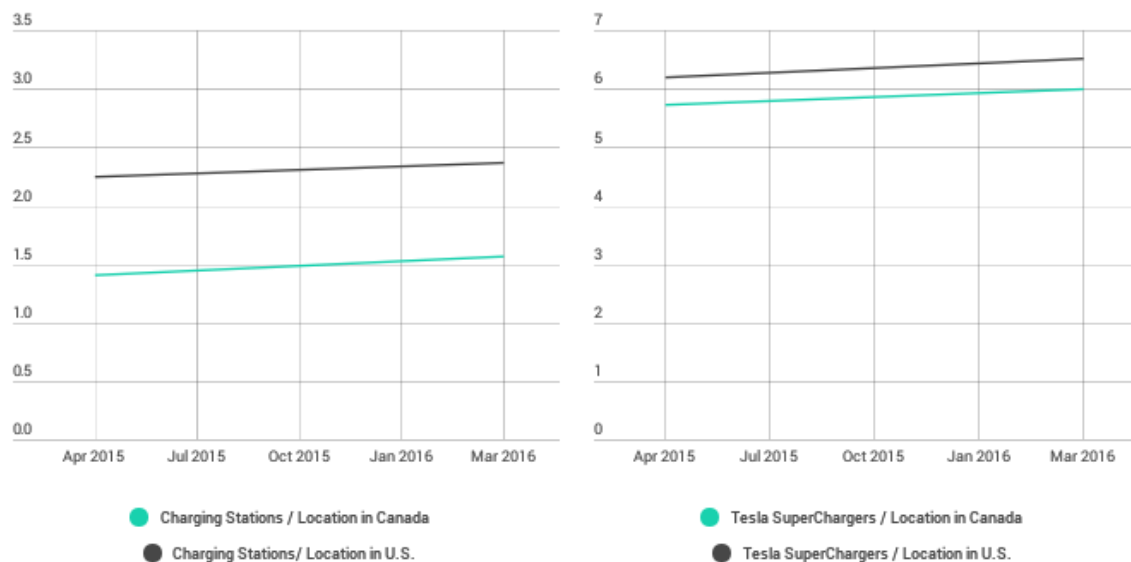


Figure 3: Avg. Charging Stations/Location & Superchargers/Location vs. Time (Canada & U.S.)

Fig. 4 and 5 below present the distribution of the number of charging stations per location in both Canada and the U.S. respectively. In both figures the plot on the left is the total breakdown of charging stations while the one on the right is the breakdown for locations added from April 2015 to March 2016.



Figure 4: Number of Charging Stations per Location in Canada (Historical Total & Last Year)

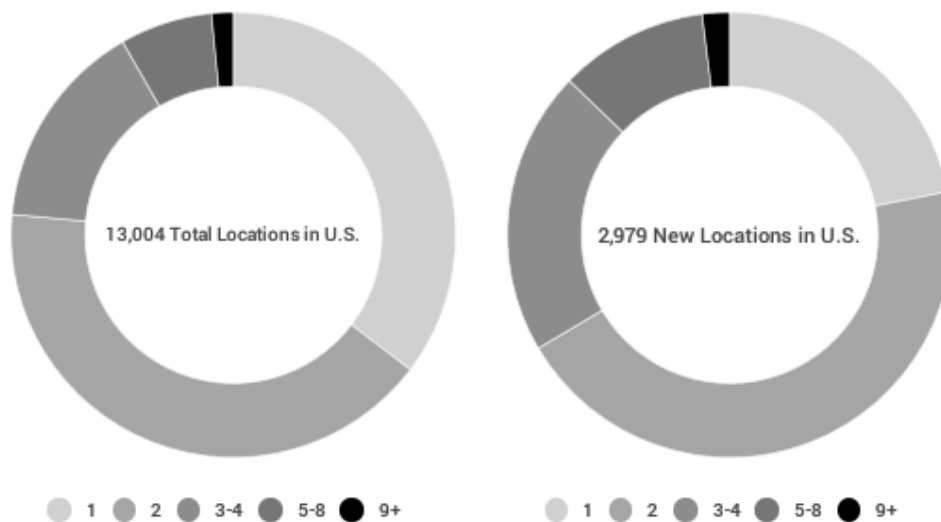


Figure 5: Number of Charging Stations per Location in U.S. (Historical Total & Last Year)

Canada has over half of its locations with only one charging station on site while the U.S. has a majority of locations with multiple charging stations installed already. The costs associated with the installation of a public charging station are non-negligible. Given that these costs tend to decrease on a per unit basis in a given location (for simultaneous installations), one would expect installers wanting to “future-proof” a location for an increasing amount of EV traffic to install multiple charging stations in one location.

As seen in Fig 3 this is likely the approach taken by Tesla with its Supercharger installations. Gradually, other station installers seem to be following Tesla’s approach but the gap is still substantial. Fig. 4 & 5 clearly show that, percentage wise, locations with only one station are decreasing compared to the historical average. As discussed in section 3.3.3 this is good news from a charging UX point of view.

Not all stations are equal. One big differentiator is the power level. A DCFC can charge an EV much faster than an L2 station. In the past year, the U.S. has increased the percentage of locations where DCFC are available. Meanwhile in Canada, the number of DCFC installations has grown at the same pace as the L2 installations. Therefore, the percentage of locations with a DCFC in Canada has remained stable at 4% while it grew from 9.5% to 13% in the U.S.. Fig. 6 below illustrates the current status in terms of available power levels per location in Canada & the U.S..

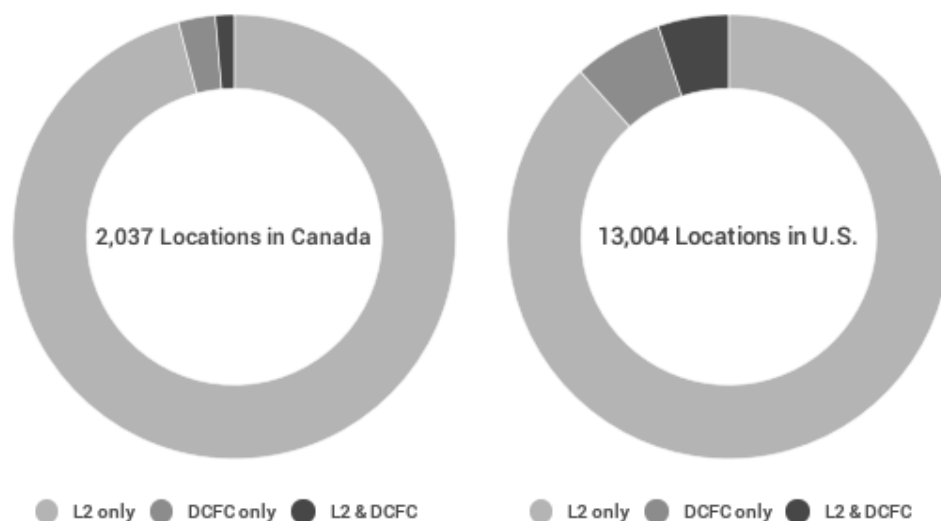


Figure 6: Available Power Level(s) per Location (Canada & U.S.)

Another differentiator between charging stations is their communication capabilities. There is a large spectrum of possibilities ranging from no communications whatsoever with the outside world to the potential of remotely changing almost every parameter on the station in real time based on various inputs. For the sake of this paper we're only dividing the stations into two categories: non-networked stations (i.e. no remote logging/control) and networked stations (some form of remote logging/control). As seen in Fig. 7 currently, in Canada less than half of the active charging stations are networked stations. In the U.S., almost two thirds of charging stations are networked.

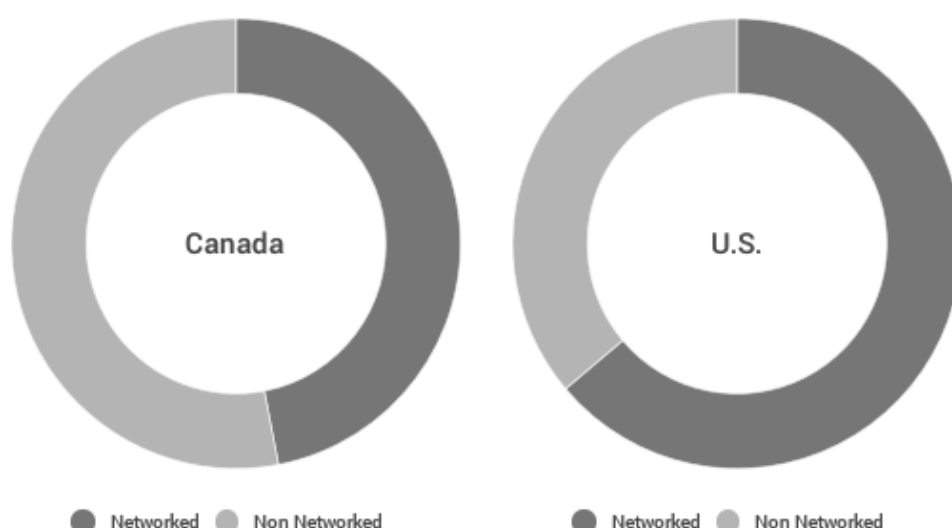


Figure 7: Networked vs. Non-Networked Charging Stations (Canada & U.S.)

There is usually a substantial cost difference for a station owner between a networked and a non-networked station. This cost difference is seen both at the time of purchase and post-purchase where networked stations usually have an operator recurring fee. As discussed in section 3, a more expensive networked station does not necessarily translate into a better charging UX.

Based on our analysis, the network vs. non-network aspect doesn't seem to have much of an impact on charging UX, however, the location types where the charging stations are installed does seem to have an impact on charging UX. Fig. 8 below gives a breakdown of locations by type. This breakdown is almost identical in Canada and the U.S..

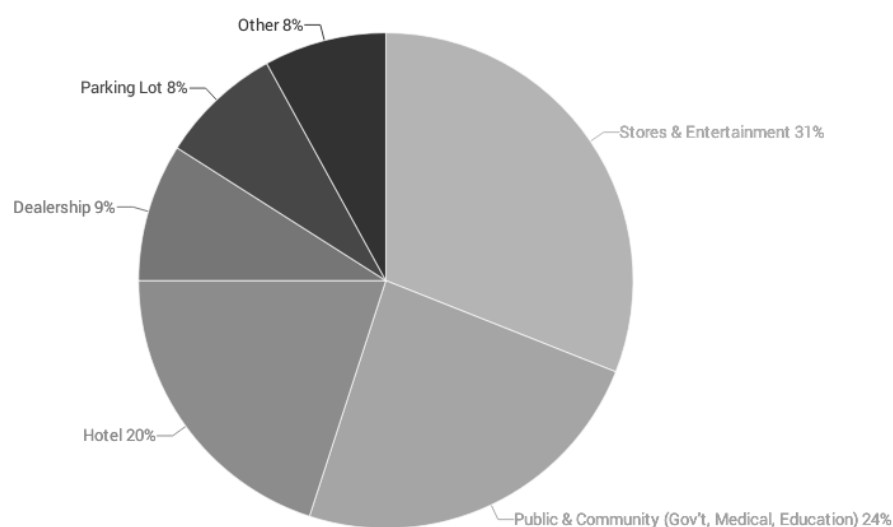


Figure 8: Charging Stations Locations Breakdown by Type (North America)

### 3 User Experience (UX)

Some location types and some regions seem to be more prone to negative user experience (UX) than others. A review of thousands of user comments on ChargeHub shows the following sites have the highest total number of negative UX comments.

1. Public & Community locations
2. Stores & Entertainment locations
3. Auto Dealerships

On a per station basis, for categories with more than 2000 stations, these are also the top three issue prone location types.

At the opposite end of the spectrum, hotels have one of the lowest ratios of negative UX comments per station.

In total there are more negative UX comments at free charging stations than paid ones, however on a per station basis, the difference is minimal. Networked and non-networked stations also have a similar number of negative UX comments on a per station basis.

Our research does not indicate that from a user's point of view, having a networked or non networked station has a substantial impact on UX. One UX advantage of networked stations is that they can often provide some information about their availability status. However, the complexity and the hassle of having to deal with multiple accounts, as well as other networked stations limitations in terms of access authorization can often outweigh any advantages from a user's UX point of view.

A location with a sufficient number of reliable non networked charging stations that is being looked after on a regular basis by onsite staff is believed to be the best UX/Cost ratio available. Interestingly, a very similar model has been the dominant model for gasoline and diesel fuelling infrastructure for many years.

#### 3.1 Common Issues

The two most common issues faced by users are:

- Inaccessible stations
- Station not working

#### 3.2 Causes

According to ChargeHub users, inaccessible stations are mainly due to:

- Poor signage
- Hostile hosts

Poor signage includes locations without EV reserved space and locations with missing or "cryptic" ground or above ground signage.

Hostile host, tend to be locations where a larger governing body has imposed charging stations to a number of affiliated sites without complete site operator buy-in.

In-terms of non-working stations, ChargeHub users reported the issues where mostly due to:

- Broken stations
- Complex activation

Broken stations can have an almost infinite number of causes ranging from physical damage to network issues.

There is a blurred line between network issues and overly complex station activation. Since there is no standardization on station activation, it is not uncommon for users to have issues activating a station. Without proper 24/7 help to do so, many drivers drive away frustrated after failing to charge.

### 3.3 Solutions

#### 3.3.1 Signage

Signage issues can often be fixed at a relatively low cost. When signage solutions are well implemented and combined with enforced by-laws they can eliminate a lot of the issues associated with station access.

Best practices for signage include a combination of both solid ground colouring and clear above ground signage with a large standard no parking sign below which by-law penalty and exception for charging EVs is indicated. Custom signage that does not include a large standard “no parking” sign is not recommended.

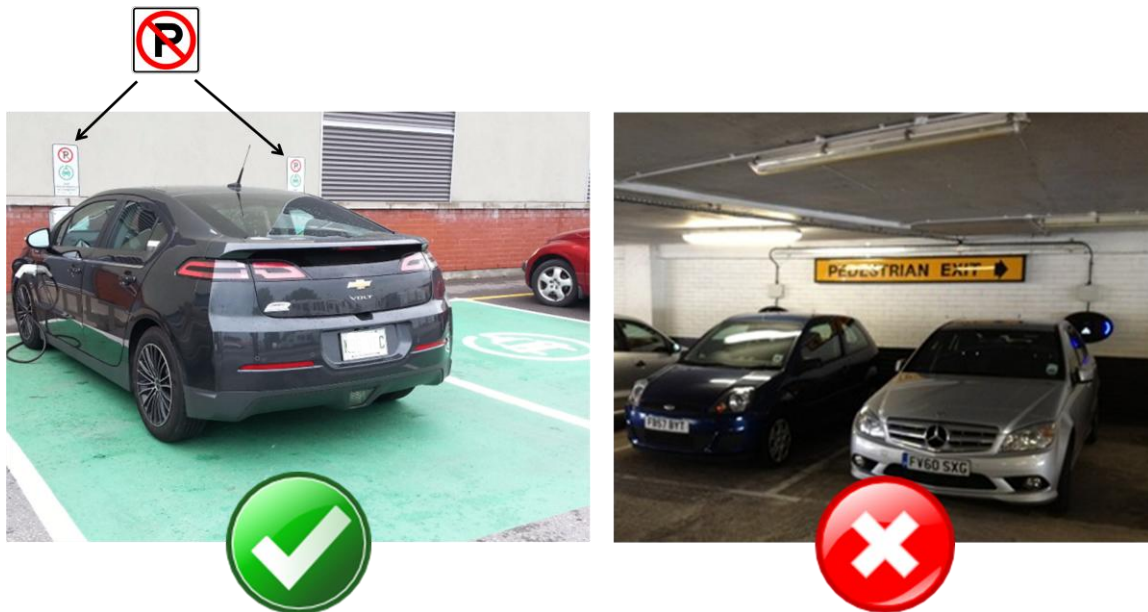


Figure 9: Do's and Don'ts of Charging Station Signage

#### 3.3.2 Hostile Hosts

Any organization thinking of implementing new charging stations **must** ensure site operator buy-in. Failure to do so will likely do more harm than good to the EV movement and to the organizations itself. There are many well documented cases of franchisees (retail and dealerships) where the franchisor's “pro-EV” image is being torn apart by EV drivers who are suffering from bad UX at locations where franchisees were imposed charging stations and they are pushing back by blocking or heavily restricting the station use.

#### 3.3.3 Broken Stations & Complex Activation

Prior to purchasing and installing a public charging station, it is important to assess the location and the type of usage the station will see. Street side charging in the downtown core of a large metropolitan area with potential for snow accumulation has very different needs than a small rural “mom and pop’s” shop in the country side in the southern U.S. Thorough analysis of the situation is required and one should seek independent advice and references prior to committing to a purchase. The larger the purchase the more time should be spent researching the options with independent sources.

Despite all efforts to have the best possible installation to minimize UX issues due to a broken station or activation issues, these problems can (will...) still surface. The best way to minimize occurrence and downtime in the case of a problem is to have a site host that is passionate about the charging station and that oversees it on a day-to-day basis. This, combined with rapid access to onsite technical support if required, is key to minimizing downtime.

From a user perspective, a location with a station that goes down every day but that has a dedicated on-site caretaker that can make it operational again within minutes has a better user experience than a station that goes down every month but has no one on site that does anything about it for days.

Another strategy to improve user experience is to install multiple charging stations in a given location. Doing so has many advantages. From a charging station owner's point of view this usually minimizes the installation costs per station. From a user's point of view this increases the likelihood that a station will be functional and accessible at any given time. This multi station strategy combined with minimal barriers to activation is a powerful combination in order to offer good charging UX. Tesla is currently extensively using this approach with its Supercharger installations.



Figure 10: Tesla Supercharger Location with 8 Stations

## 4 The Ultimate Charging Station UX Checklist

If planning one or multiple new charging station installations or if assessing existing installations to improve usage and UX, one should do everything possible to be able to put a checkmark next to each item on this 5 point check list:

- ☐ **On site staff:** Have total buy in from on site staff, provide appropriate training on the station(s), have procedures in place to verify station on a daily basis and for rapidly taking care of issues as they arise.
- ☐ **Signage:** Ensure there are clear no parking signs next to charging station(s) with an exception for vehicles in the process of charging and have the reserved parking area clearly marked with high visibility paint on the ground. Ensure area is well lit. Enforce parking rules.
- ☐ **Information:** Ensure that information platforms used by EV drivers in the area (ex: ChargeHub) have the most up-to-date and accurate information about your location including pictures.
- ☐ **Redundancy:** Have as many charging stations as the location and the budget will permit.
- ☐ **Activation:** Minimize barriers to activation. In order to do so, ask yourself the following question: If a recent EV buyer from 2000 miles away (in any direction) was parachuted here at 4am with an EV, could this person easily activate this station?

## 5 Conclusion

The discussion around public EV charging is often dominated by the subject of the quantity of charging stations. However, quantity is only part of the story when it comes to EV charging. Quantity is good, but it alone does not define a region's "chargeability". The quality of the user experience at charging stations in a region is a key, yet often overlooked, aspect of public EV charging. It is only when both quantity of charging stations and UX quality are high that a region's "chargeability" is good.

Through graphs and up to date data presented in section 2, this paper showed that in terms of charging stations quantity, things are progressing at a fast pace in both Canada and the U.S.. Unfortunately, as organizations throughout North America, driven by various motives, race to install new charging stations, considerations for charging UX quality are often forgotten or pushed aside.

Section 3 presented some of the most common UX issues faced at public charging stations in North America and proposed means to mitigate them. Most of these solutions can be implemented for a lower cost than adding a new EVSE with all the "bells and whistles" in a new location. Therefore, authors strongly encourage any new station installers to plan their implementation of the best UX practices starting on day 1 of any new public EVSE project. Furthermore, the authors would recommend that existing station owners assess their current installations in terms of UX and address any deficiencies prior to installing new charging stations.

In order to help current and future station owners and other stakeholders ensure top quality charging UX at their stations, section 4 presented a simple five point checklist to ensure new and existing public charging locations can provide great UX to a maximum of EV drivers.

One of the best forms of advertisement for EVs is to have non-EV drivers constantly see delighted EV drivers charging their car in public places. The only way to achieve this is by maximizing UX quality throughout North America's public EV charging infrastructure.

## References

All the data used in this paper is sourced from the ChargeHub Data service ([chargehub.com](https://chargehub.com)) and is current as of March 2016. Subjective UX data has been correlated with observations from Brian Kent (EV Roadtrip World Record Holder), EV association representatives, and officials responsible for large public EVSE deployment projects.

The image of a bad signage situation in Fig. 9 comes from [www.contracthireandleasing.com](http://www.contracthireandleasing.com) (accessed May 2015)

## Authors



Simon Ouellette holds a PhD in Mechanical Engineering from McGill University. His academic background is in powertrain modelling and simulation of electric and hybrid vehicles in off-road environments. He co-founded Mogile Technologies Inc with Olivier Proulx and Francis De Broux in 2013 to tackle unique problems facing the EV industry. One of these problems is EV driver UX at public charging stations. Mogile's solution is ChargeHub.



Olivier Proulx holds a Bachelor in Electrical and Software Engineering and a Master's in Mechanical Engineering with a focus on plug-in hybrid vehicle control strategy. He currently leads the technical development of the ChargeHub platform.



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